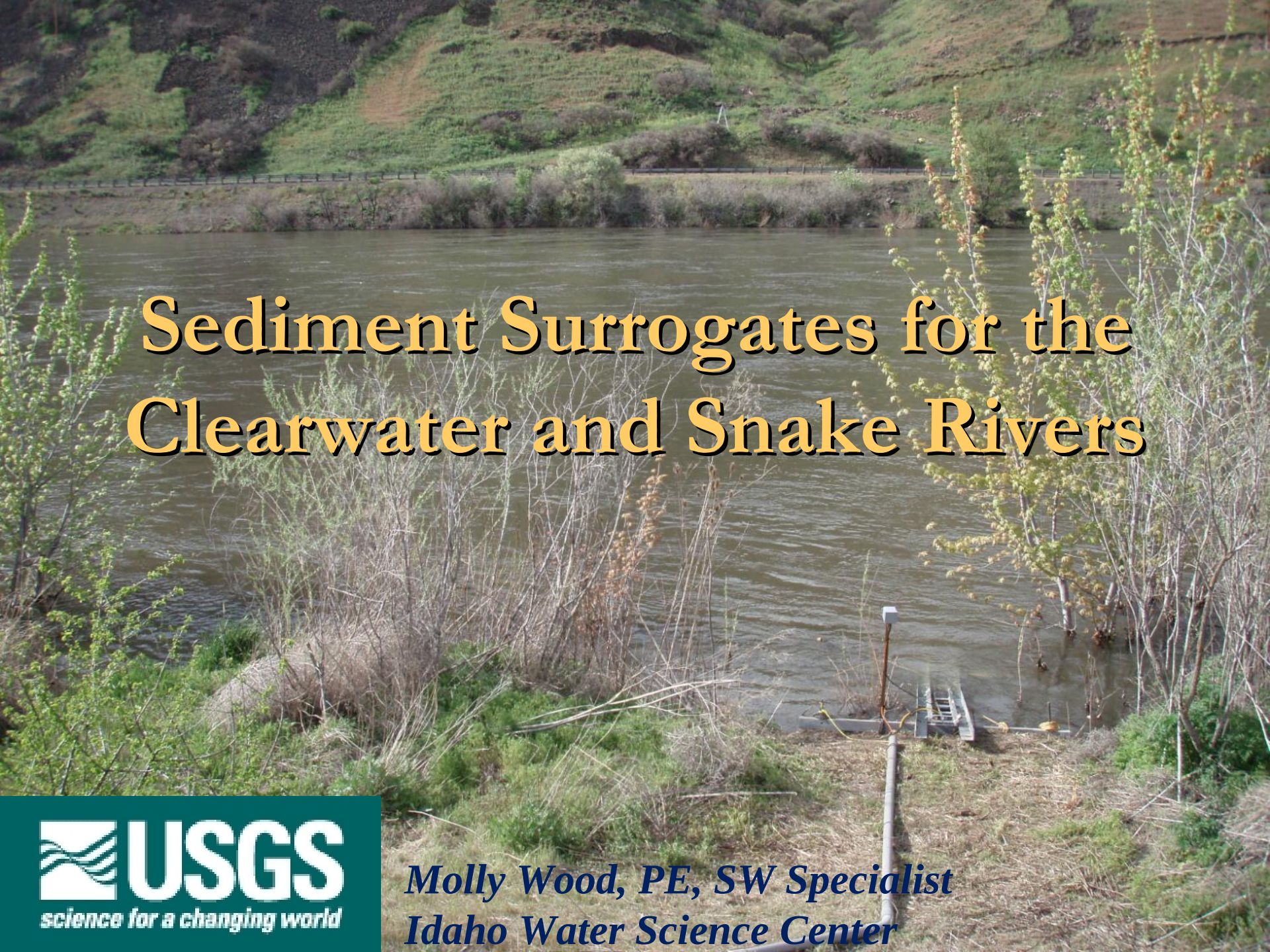

Sediment Surrogates for the Clearwater and Snake Rivers

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Molly Wood, PE, SW Specialist
Idaho Water Science Center

Basic Concept

- Need for indirect, continuous measurements of sediment
- Can we relate “surrogate” parameters to sediment?
- Promising techniques:
  - Backscatter from acoustic velocity meters
  - Laser diffraction
  - Turbidity
- May work well when sediment – flow relationship is unstable

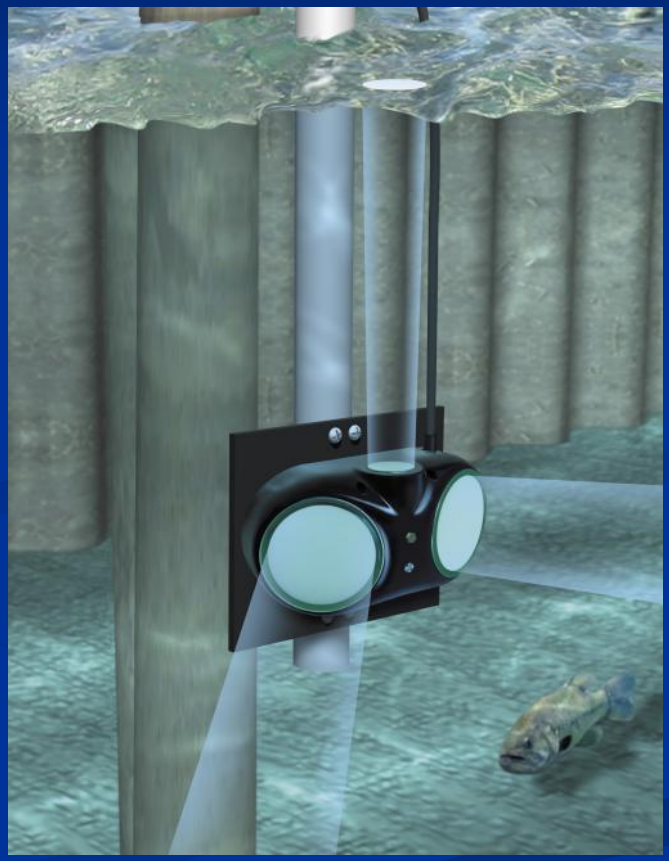

Photo courtesy of Sontek

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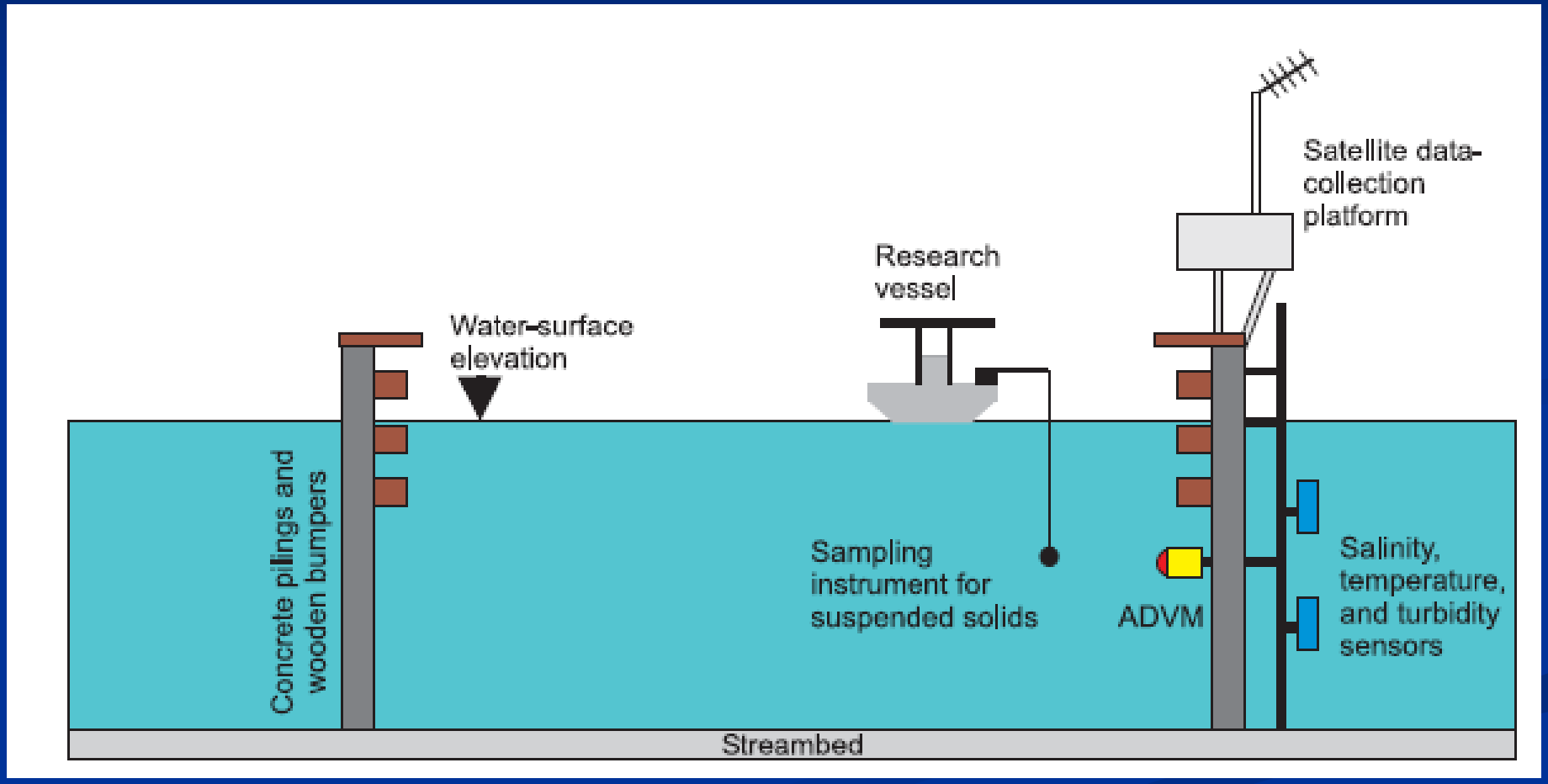
Example Data Collection System



Courtesy of Eduardo Patino, USGS Florida

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Surrogate Technologies

- Acoustics
  - Pros: Profiling, no biofouling
  - Cons: Need for multiple instruments in some cases, insensitivity at low concentrations, difficult data corrections
- Laser Diffraction
  - Pros: Real-time particle size and SSC
  - Cons: Biofouling, requires dilution > 3,000 mg/L, point measurement
- Turbidity
  - Pros: Well-tested, relatively cheap and easy
  - Cons: Biofouling, calibration needs, point measurement

Snake and Clearwater Rivers

- *Purpose*: Study sediment sources as part of sediment management program for Lower Granite Reservoir
- Installed surrogate gages in May 2008
- Clearwater River – "Supergage"
  - Acoustics, turbidity, laser
  - Variable grain size distribution
- Snake River – Turbidity only
  - Mostly silt

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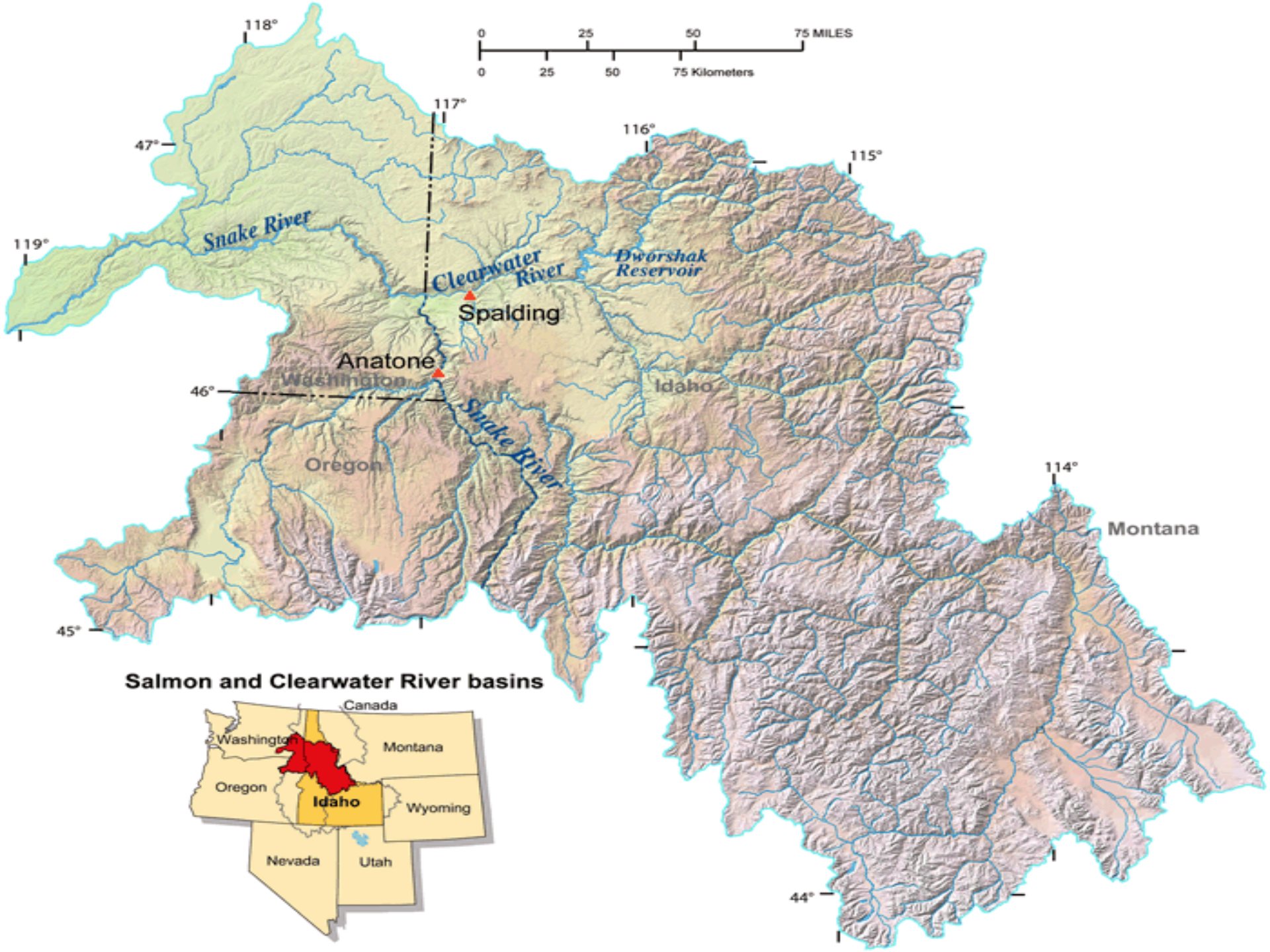
0 25 50 75 MILES
0 25 50 75 Kilometers
118°
117°
116°
115°
114°
47°
46°
45°
44°
119°
Snake River
Clearwater River
Dworshak Reservoir
Spalding
Anatone
Washington
Idaho
Oregon
Montana
Snake River
Salmon and Clearwater River basins
Canada
Washington
Montana
Oregon
Idaho
Wyoming
Nevada
Utah

Installation

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Clearwater Surrogates

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ACOUSTIC FREQUENCY VS PARTICLE SIZE

ACOUSTIC FREQUENCY	Best for:
500 kHz	Coarse sand
1.5 mHz	Medium sand
3 mHz	Silt

Lower Frequency
Appropriate
for Larger Particle Sizes

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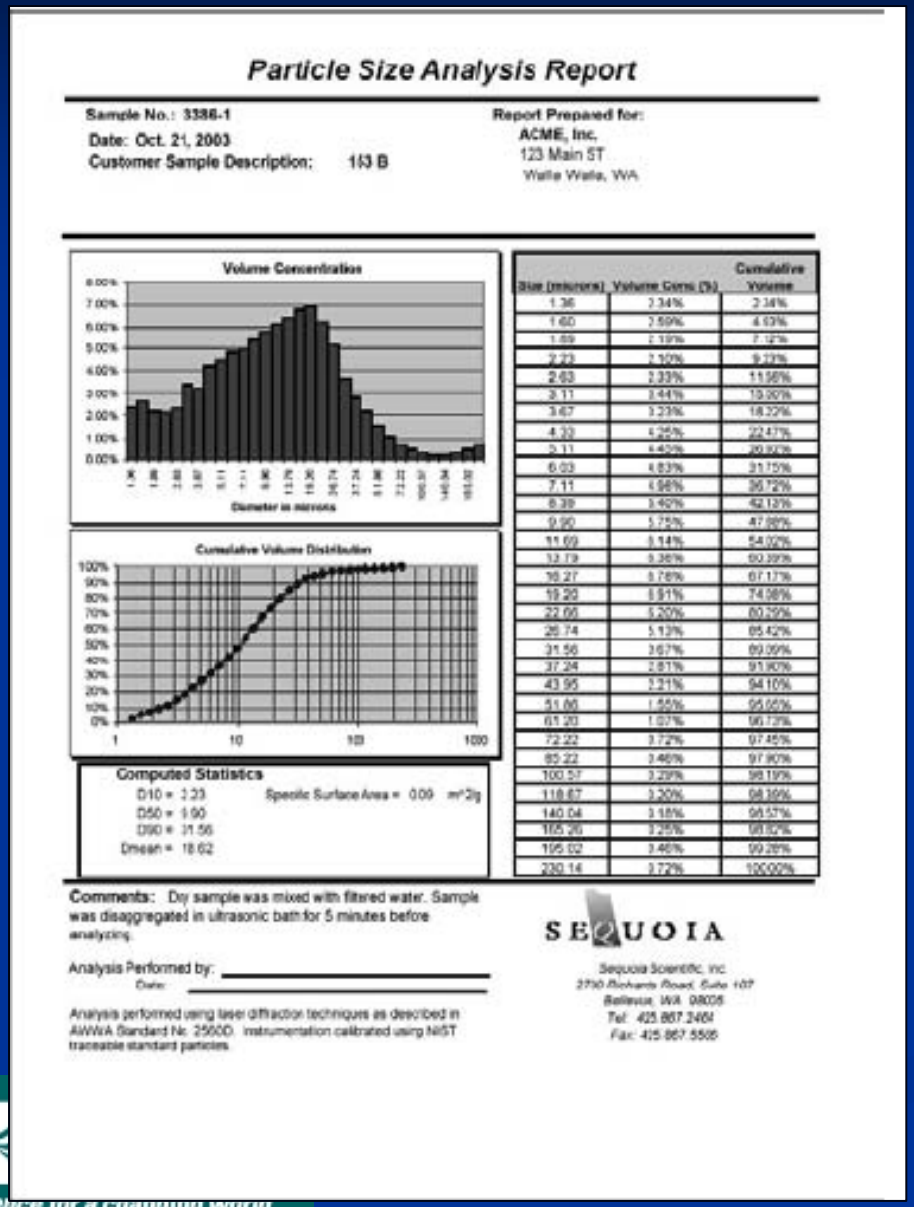
↑ Fine Mtls = ↑ Backscatter Attenuation
↑ Coarse Mtls = ↑ Backscatter

LISST Streamside



Particle Size Analysis Report

Sample No.: 3386-1
Date: Oct. 21, 2003
Customer Sample Description: 1/3 B

Report Prepared for:
ACME, Inc.
123 Main ST
Walla Walla, WA

Volume Concentration

Cumulative Volume Distribution

Computed Statistics
D10 = 1.23
D50 = 6.90
D90 = 31.56
Dmean = 18.62
Specific Surface Area = 0.00 m^2/g

Size (microns)	Volume Conc. (%)	Cumulative Volume
1.36	2.34%	2.34%
1.60	2.59%	4.93%
1.89	2.19%	7.12%
2.23	2.10%	9.23%
2.63	2.33%	11.56%
3.11	2.44%	13.99%
3.67	2.33%	16.32%
4.33	4.25%	20.57%
5.11	4.40%	24.97%
6.03	4.83%	29.80%
7.11	4.95%	34.75%
8.39	5.40%	40.15%
9.90	5.75%	45.90%
11.69	6.14%	52.04%
13.79	6.36%	58.39%
16.27	6.78%	65.17%
19.20	6.91%	72.08%
22.66	6.20%	78.28%
26.74	5.13%	83.42%
31.56	3.67%	87.09%
37.24	2.81%	89.90%
43.95	2.31%	92.21%
51.86	1.85%	94.06%
61.20	1.97%	96.03%
72.22	1.72%	97.75%
85.22	1.46%	99.21%
100.57	0.79%	100.00%
118.67	0.00%	100.00%
140.04	0.00%	100.00%
165.26	0.00%	100.00%
195.02	0.00%	100.00%
230.14	0.00%	100.00%

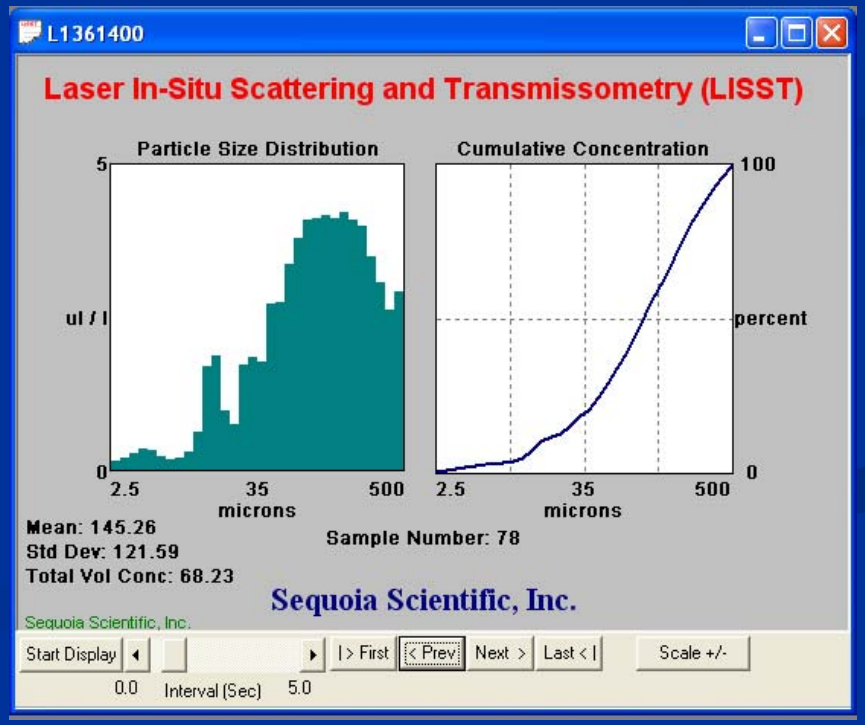
Comments: Dry sample was mixed with filtered water. Sample was disaggregated in ultrasonic bath for 5 minutes before analyzing.

Analysis Performed by: _____
Date: _____

Analysis performed using laser diffraction techniques as described in AWWA Standard No. 2560D. Instrumentation calibrated using NIST traceable standard particles.

SEQUOIA

Sequoia Scientific, Inc.
2700 Richards Road, Suite 107
Bellevue, WA 98005
Tel: 425.867.2461
Fax: 425.867.5506



PRELIMINARY RESULTS:

Clearwater River

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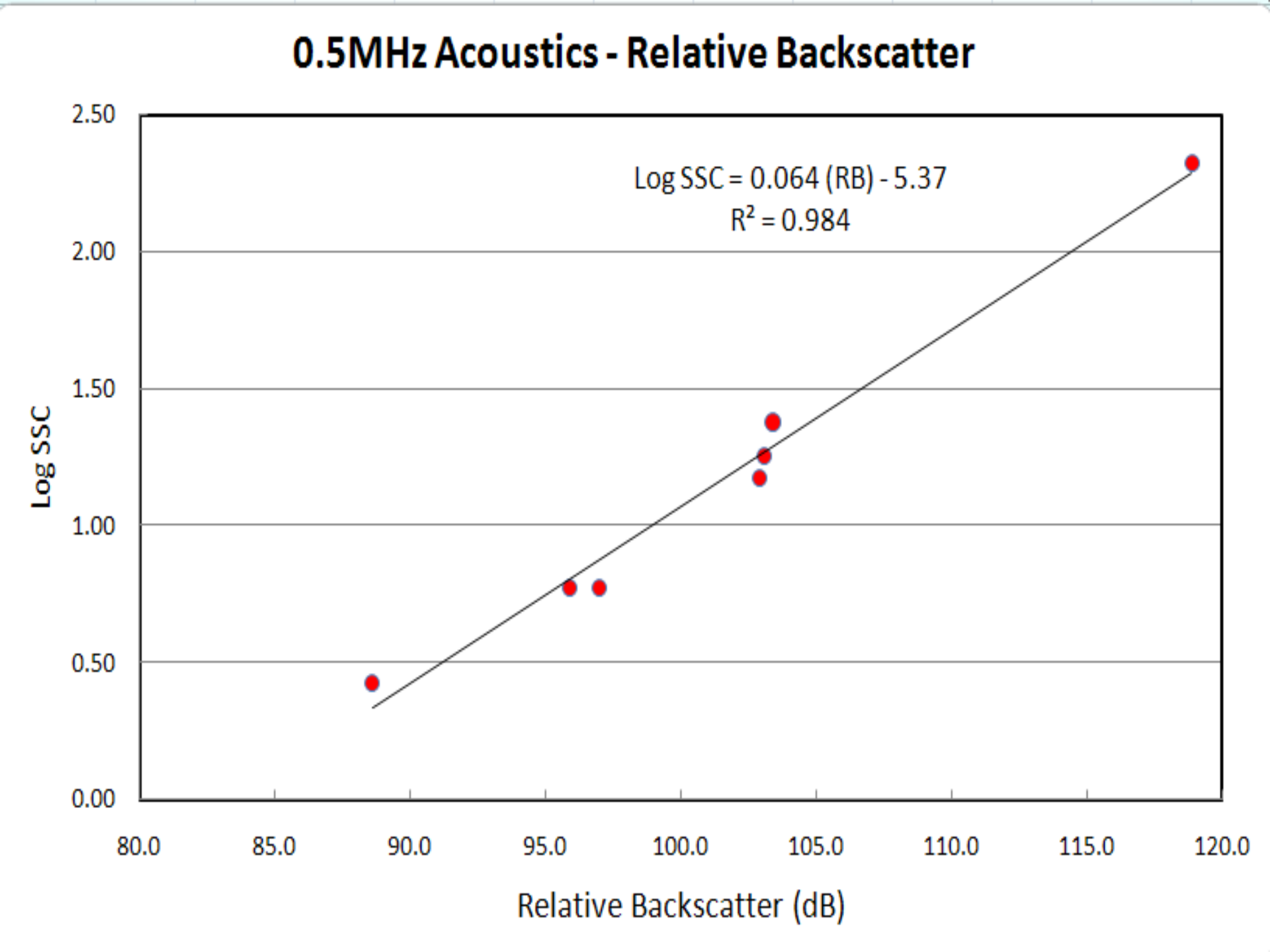
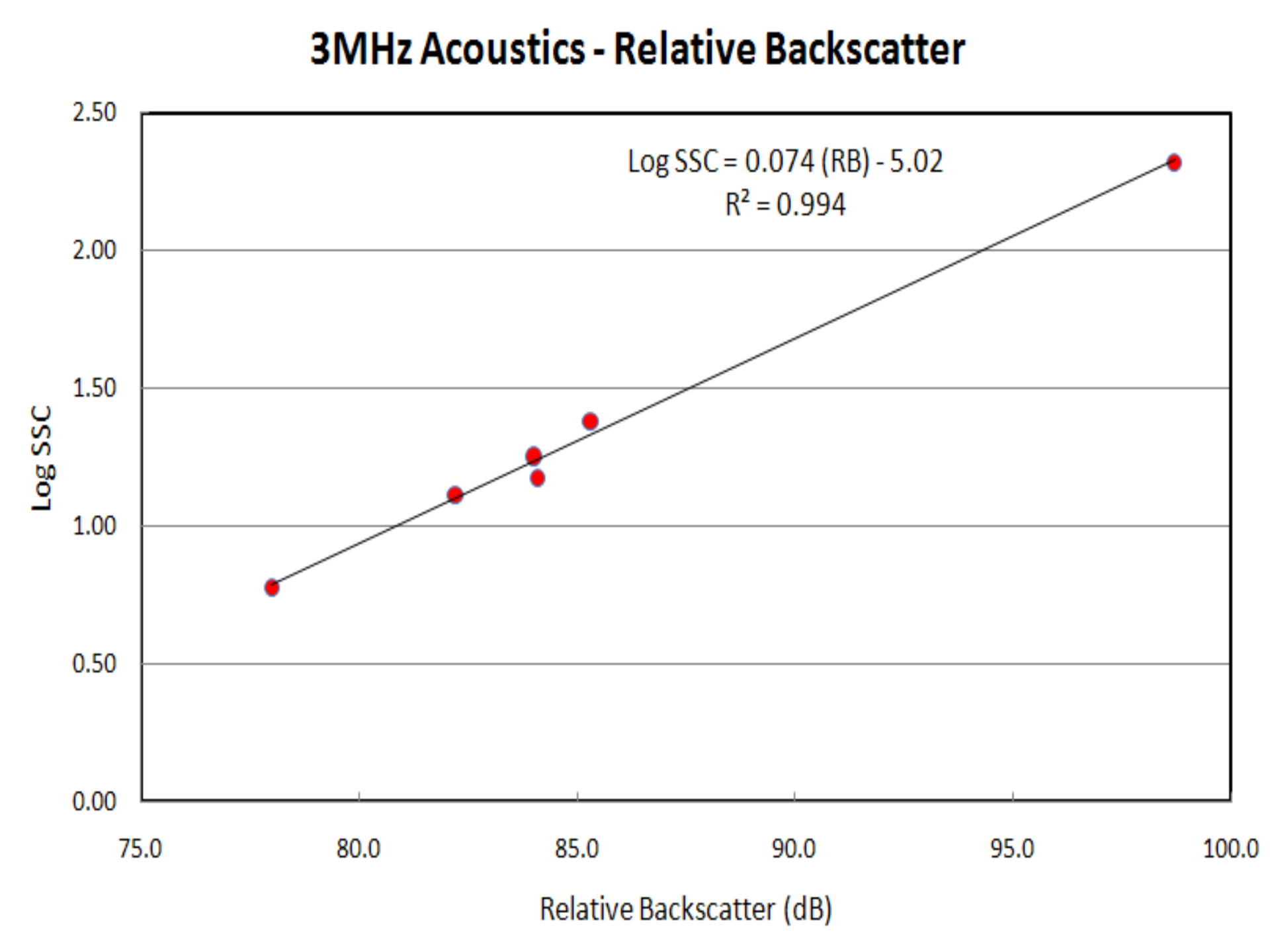
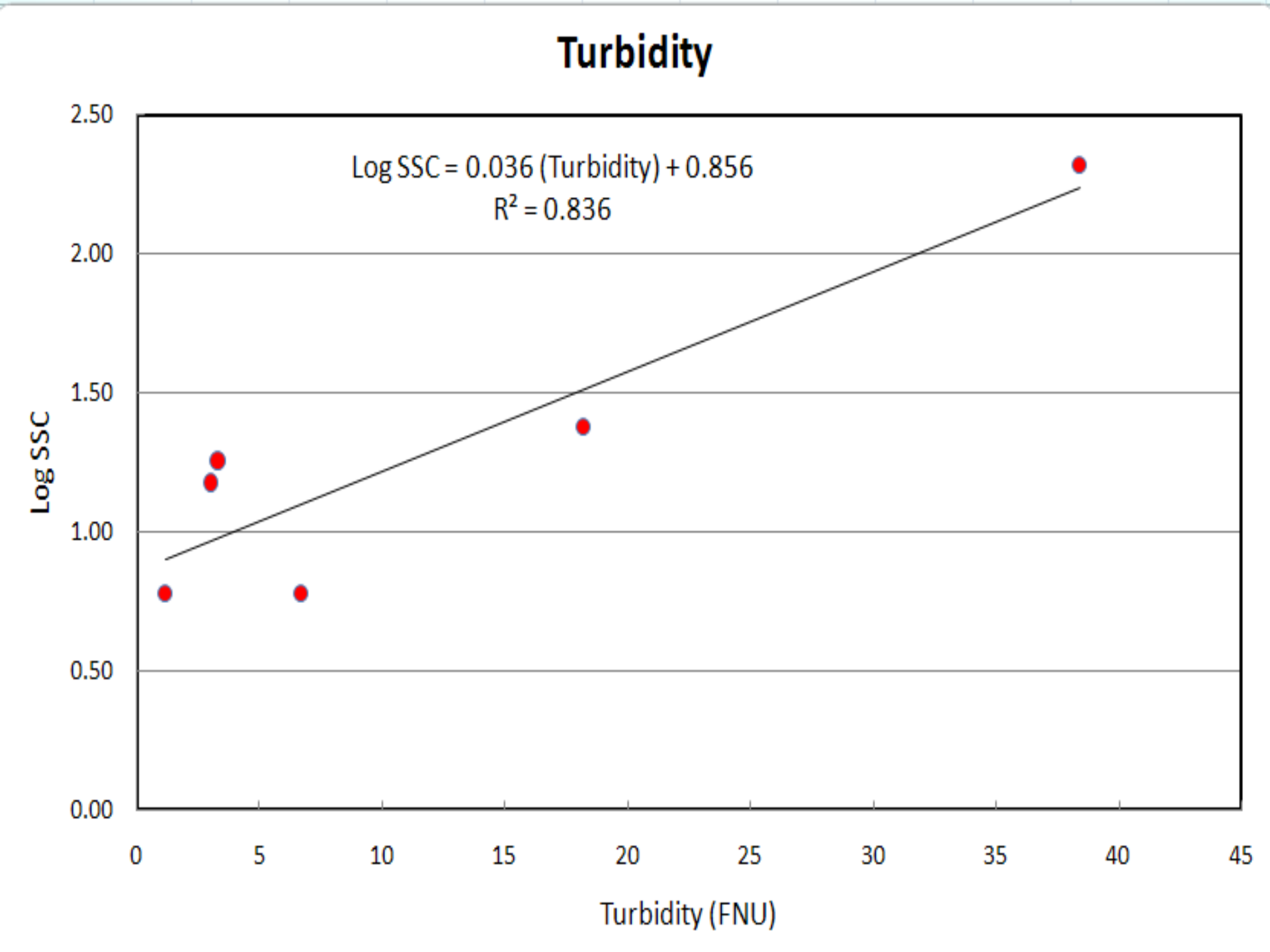
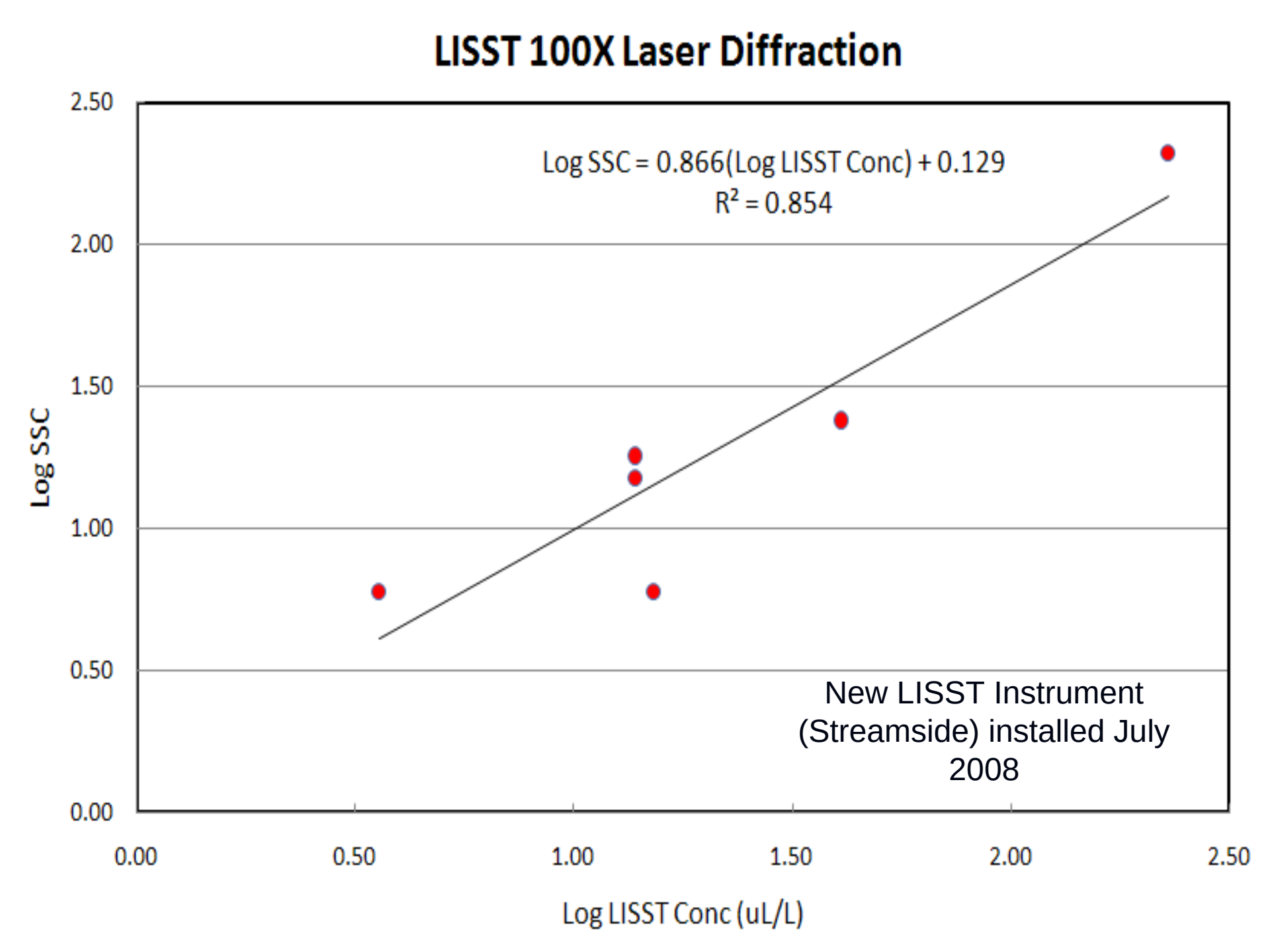
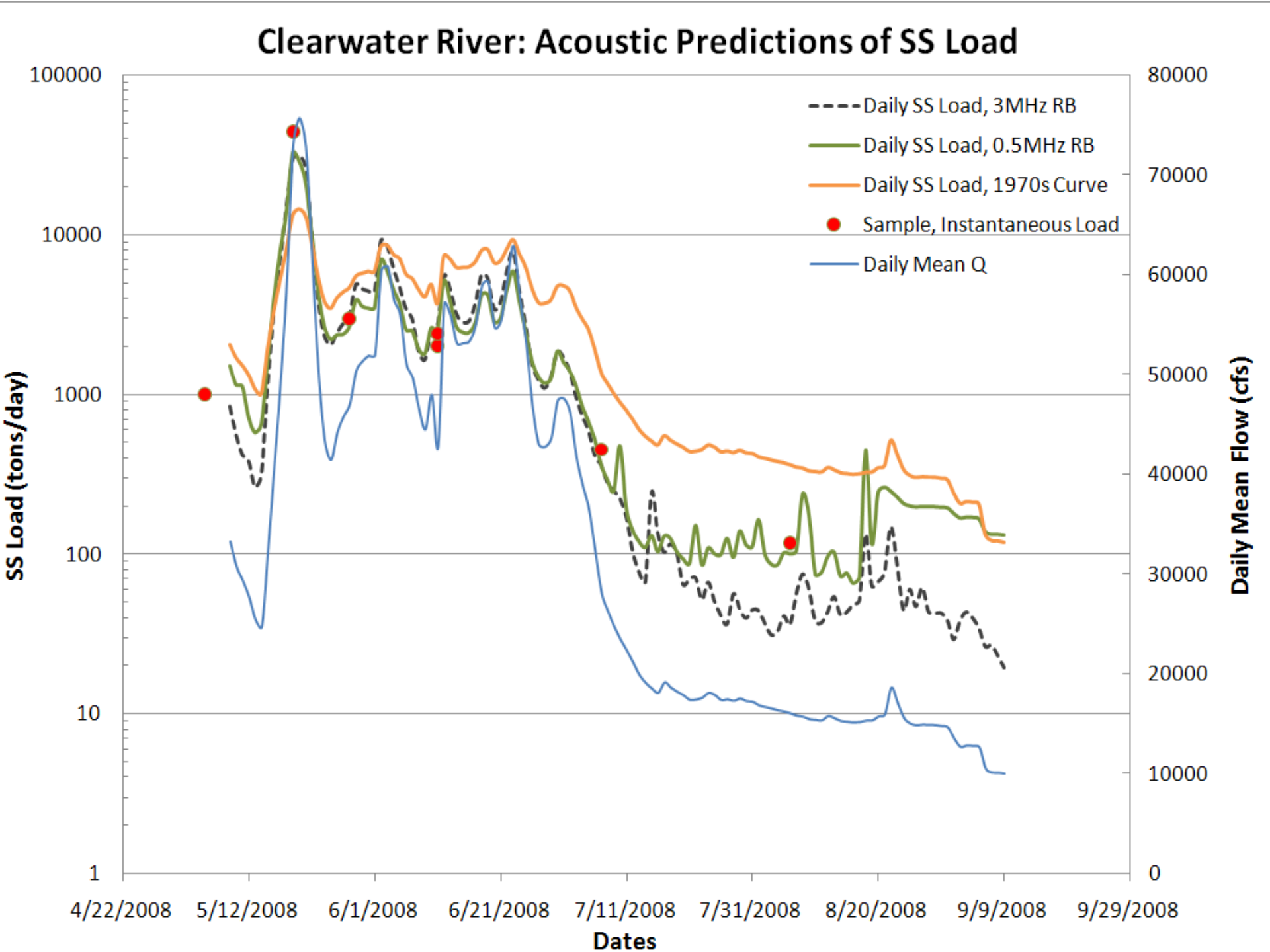

0.5MHz Acoustics - Relative Backscatter
Log SSC = 0.064 (RB) - 5.37
R² = 0.984
Log SSC
2.50
2.00
1.50
1.00
0.50
0.00
80.0
85.0
90.0
95.0
100.0
105.0
110.0
115.0
120.0
Relative Backscatter (dB)


3MHz Acoustics - Relative Backscatter
Log SSC = 0.074 (RB) - 5.02
R² = 0.994
2.50
2.00
1.50
1.00
0.50
0.00
Log SSC
75.0
80.0
85.0
90.0
95.0
100.0
Relative Backscatter (dB)


Turbidity
Log SSC = 0.036 (Turbidity) + 0.856
R² = 0.836
Log SSC
Turbidity (FNU)
2.50
2.00
1.50
1.00
0.50
0.00
0
5
10
15
20
25
30
35
40
45


LISST 100X Laser Diffraction
Log SSC = 0.866(Log LISST Conc) + 0.129
R² = 0.854
New LISST Instrument (Streamside) installed July 2008
Log SSC
Log LISST Conc (uL/L)
0.00
0.50
1.00
1.50
2.00
2.50


Clearwater River: Acoustic Predictions of SS Load
Daily SS Load, 3MHz RB
Daily SS Load, 0.5MHz RB
Daily SS Load, 1970s Curve
Sample, Instantaneous Load
Daily Mean Q
SS Load (tons/day)
Daily Mean Flow (cfs)
Dates
100000
10000
1000
100
10
1
80000
70000
60000
50000
40000
30000
20000
10000
0
4/22/2008
5/12/2008
6/1/2008
6/21/2008
7/11/2008
7/31/2008
8/20/2008
9/9/2008
9/29/2008

Preliminary Summary - Clearwater

Surrogate	R^2	Average % Difference From Measured
3MHz Backscatter - SSC	**0.994**	**+11%**
0.5MHz Backscatter - SSC	**0.984**	**-0.3%**
3MHz Attenuation – Silt/Clay Fraction	**0.921**	**+29%**
0.5MHz Backscatter – Sand Fraction	**0.985**	
Turbidity - SSC	**0.836**	**-12%**
LISST 100X - SSC	**0.866**	**-12%**
LISST Streamside - SSC	**TBA***	**TBA**
1970's Sediment Curve	**NA**	**-103%**
2008 Discharge - SSC	**0.866**	**+23%**

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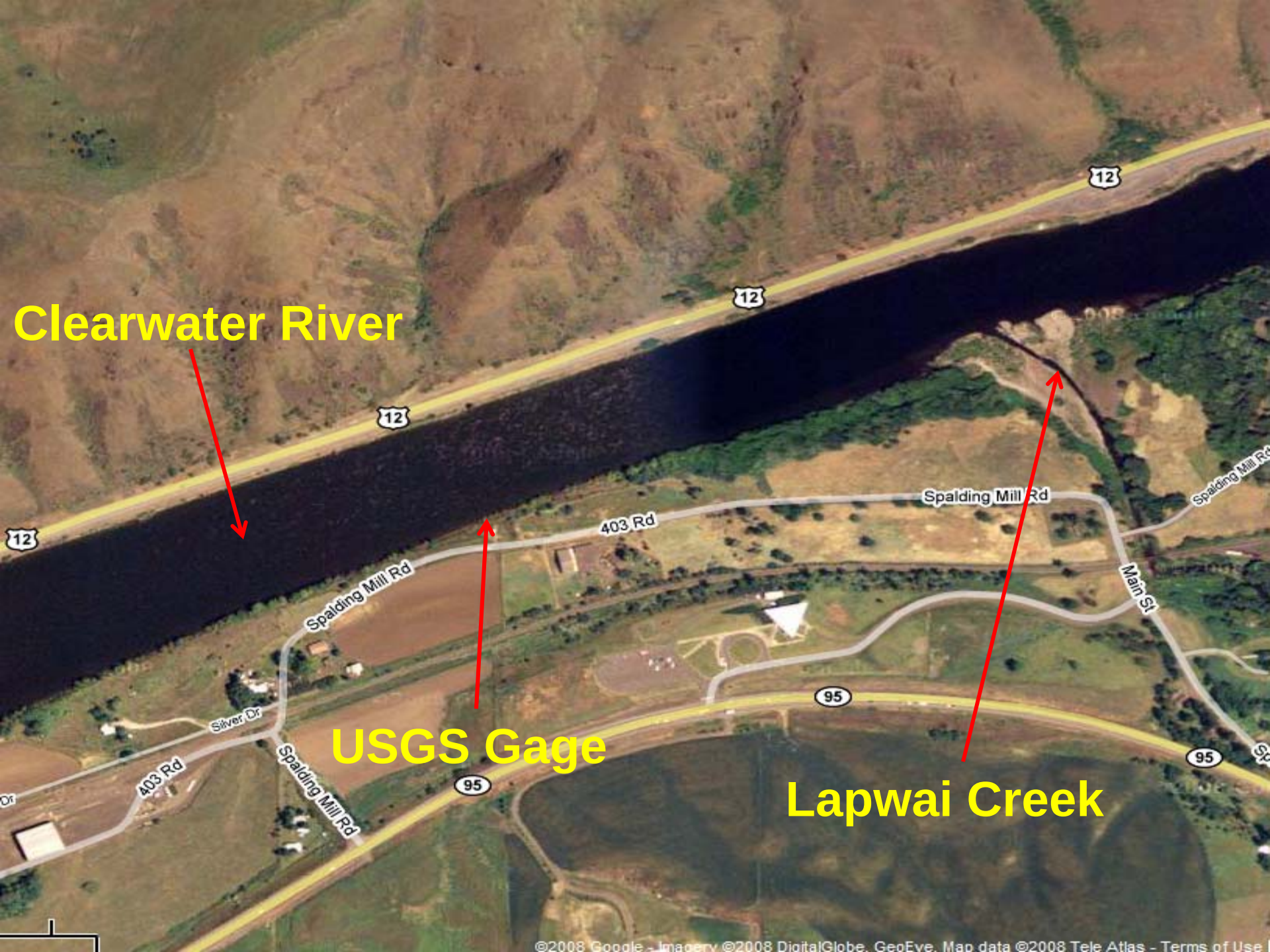
* Only 2 samples available for Streamside calibration. Results TBA.


Clearwater River
USGS Gage
Lapwai Creek
12
12
12
12
Spalding Mill Rd
403 Rd
Spalding Mill Rd
Main St
95
95
Silver Dr
403 Rd
Spalding Mill Rd
95
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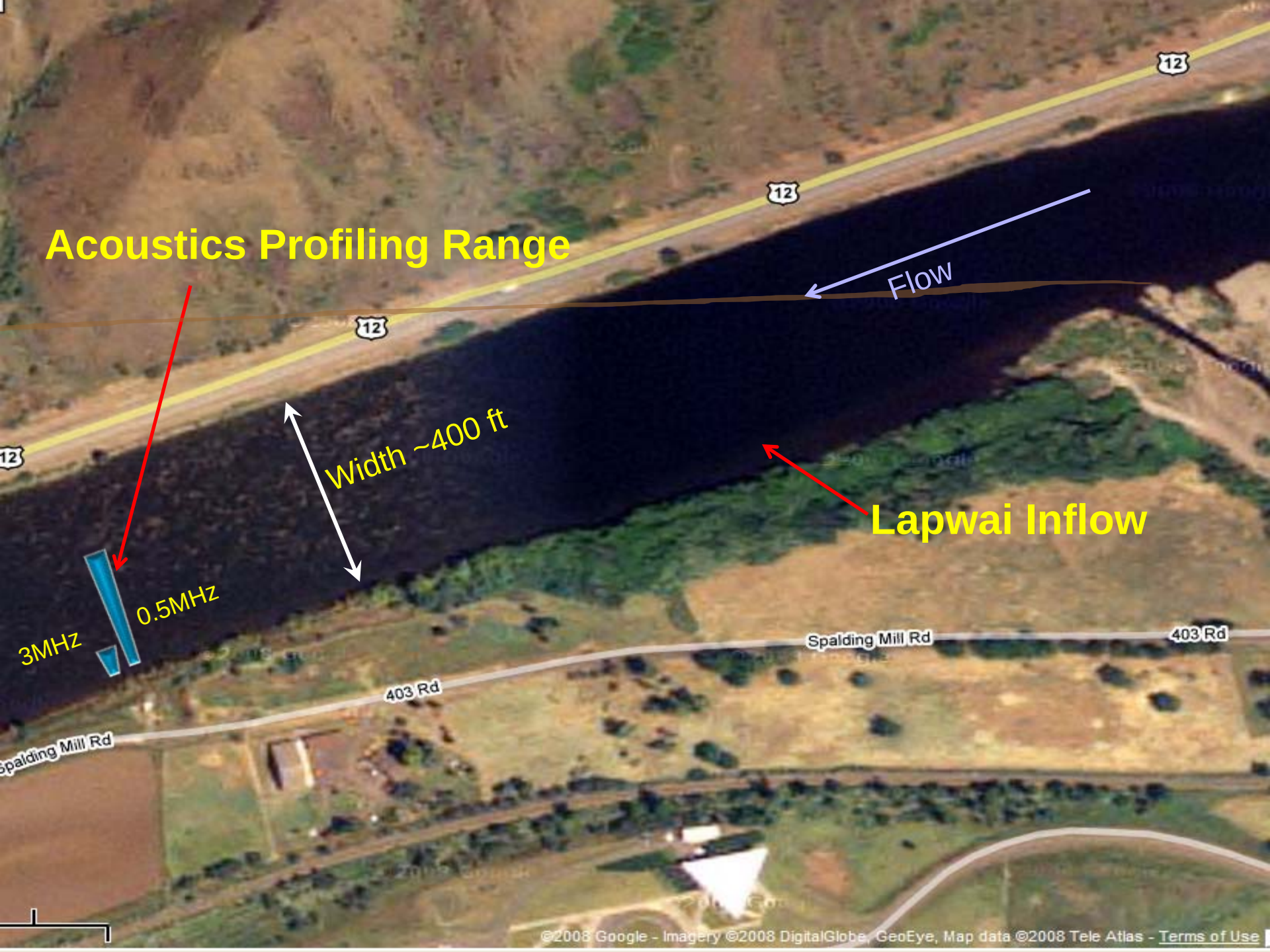
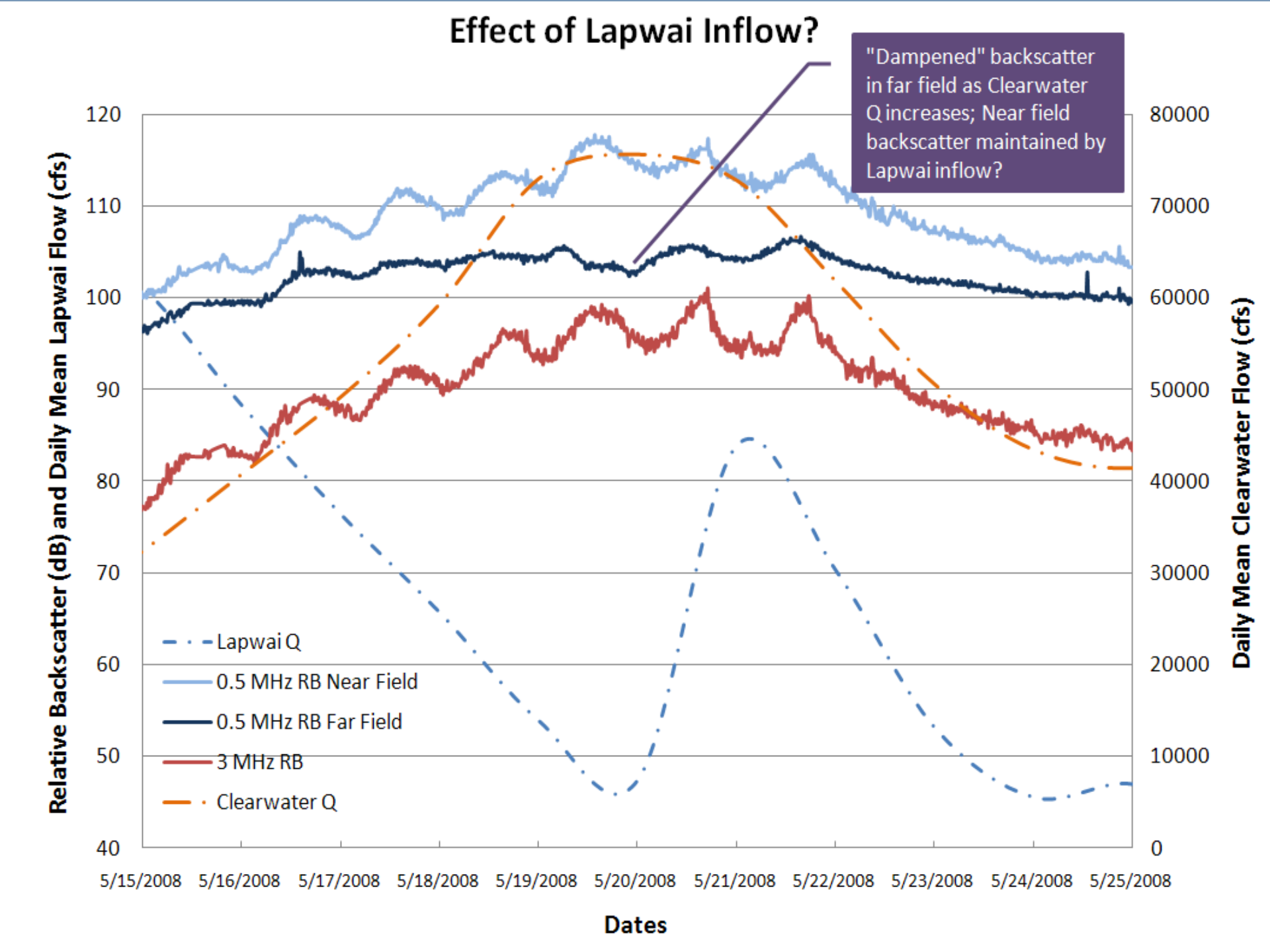
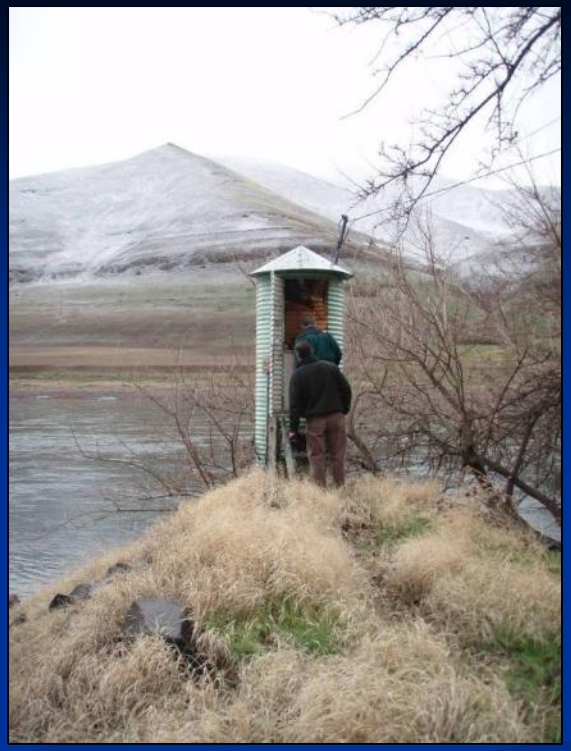

Acoustics Profiling Range
Flow
Width ~400 ft
Lapwai Inflow
3MHz
0.5MHz
Spalding Mill Rd
403 Rd
12
©2008 Google - Imagery ©2008 DigitalGlobe, GeoEye, Map data ©2008 Tele Atlas - Terms of Use


Effect of Lapwai Inflow?
"Dampened" backscatter in far field as Clearwater Q increases; Near field backscatter maintained by Lapwai inflow?
Relative Backscatter (dB) and Daily Mean Lapwai Flow (cfs)
Daily Mean Clearwater Flow (cfs)
120
110
100
90
80
70
60
50
40
80000
70000
60000
50000
40000
30000
20000
10000
0
Lapwai Q
0.5 MHz RB Near Field
0.5 MHz RB Far Field
3 MHz RB
Clearwater Q
5/15/2008
5/16/2008
5/17/2008
5/18/2008
5/19/2008
5/20/2008
5/21/2008
5/22/2008
5/23/2008
5/24/2008
5/25/2008
Dates

Snake River



YSI Sonde with Turbidity Probe

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PRELIMINARY RESULTS:

Snake River

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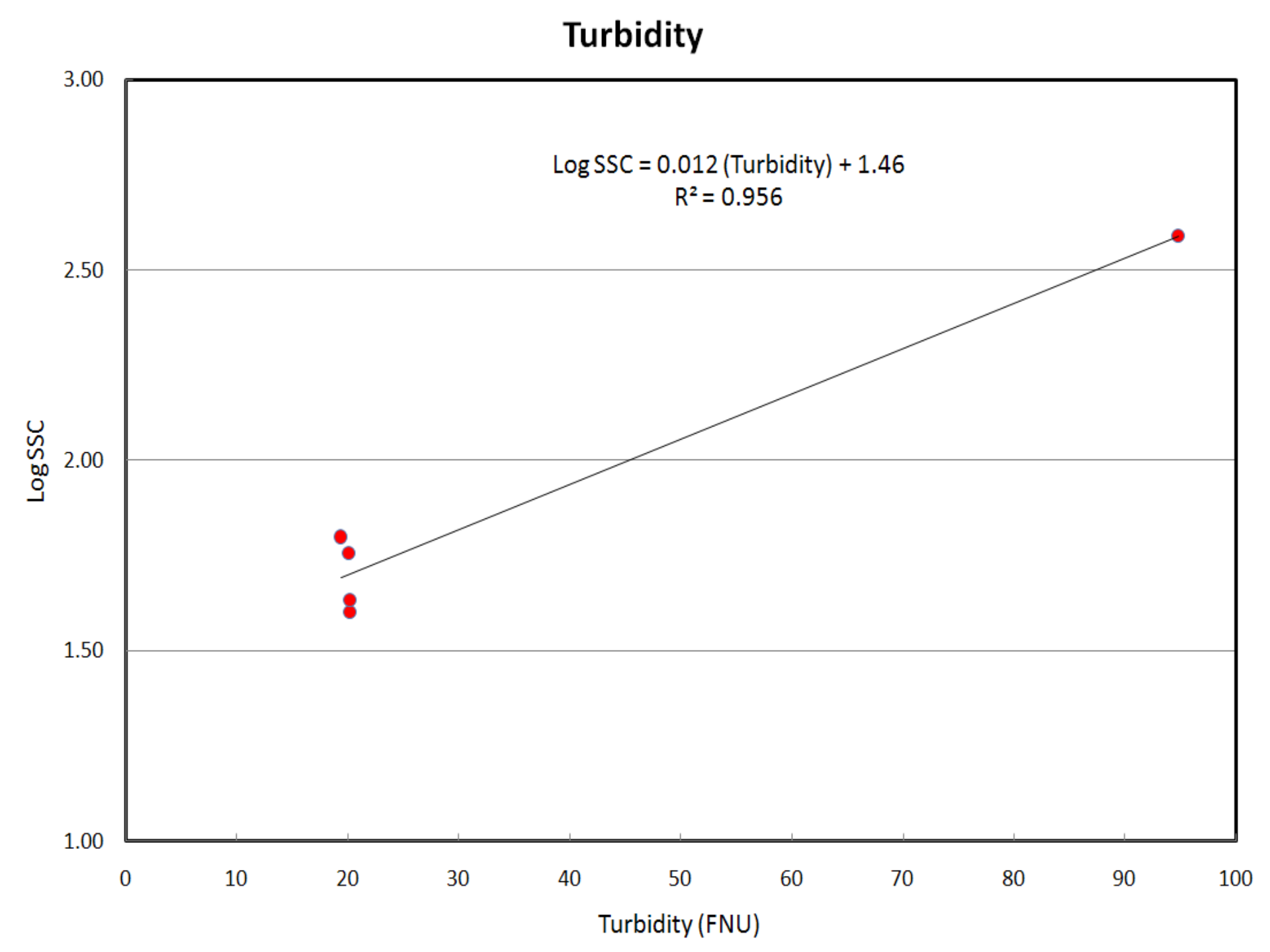
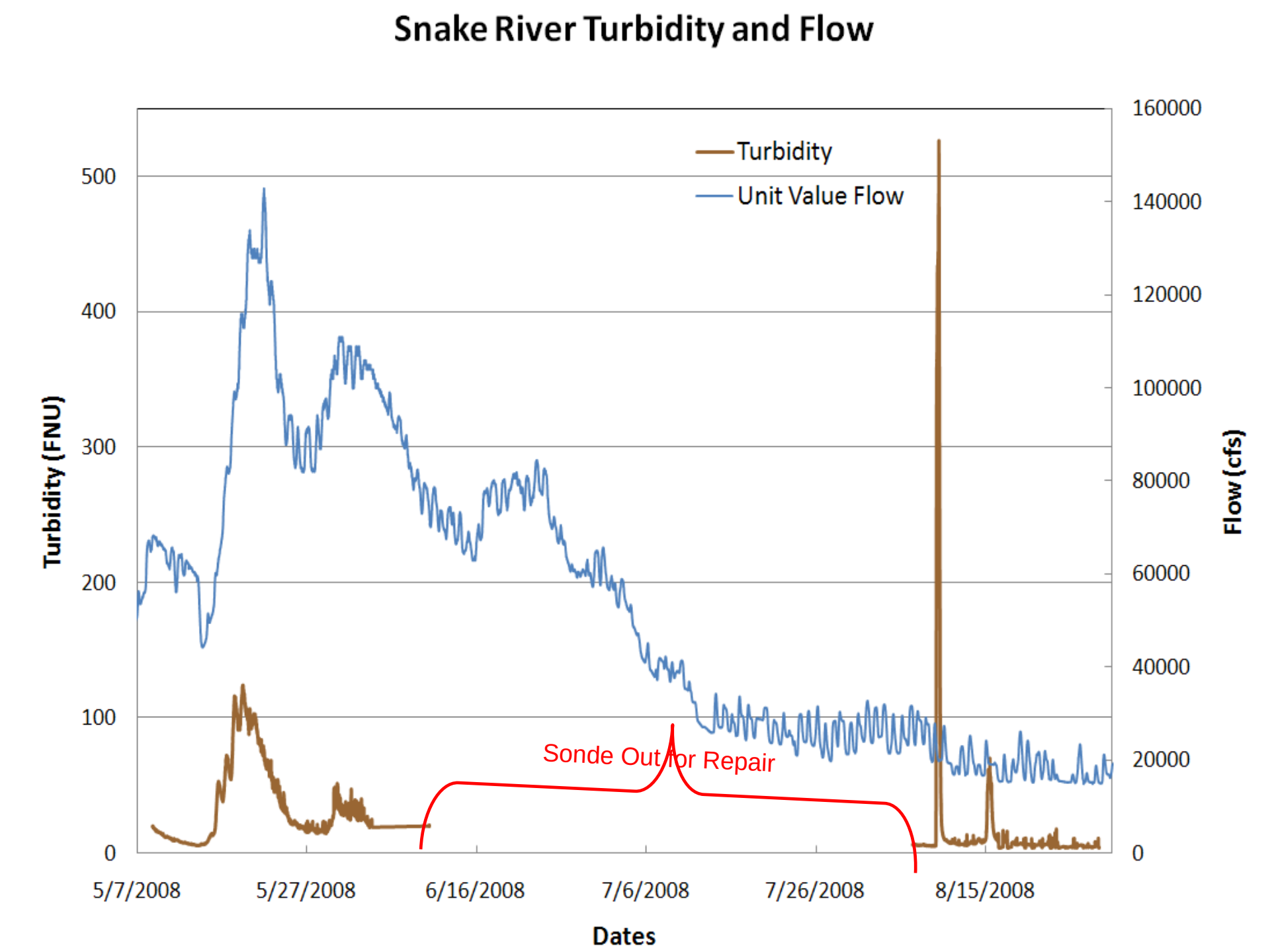
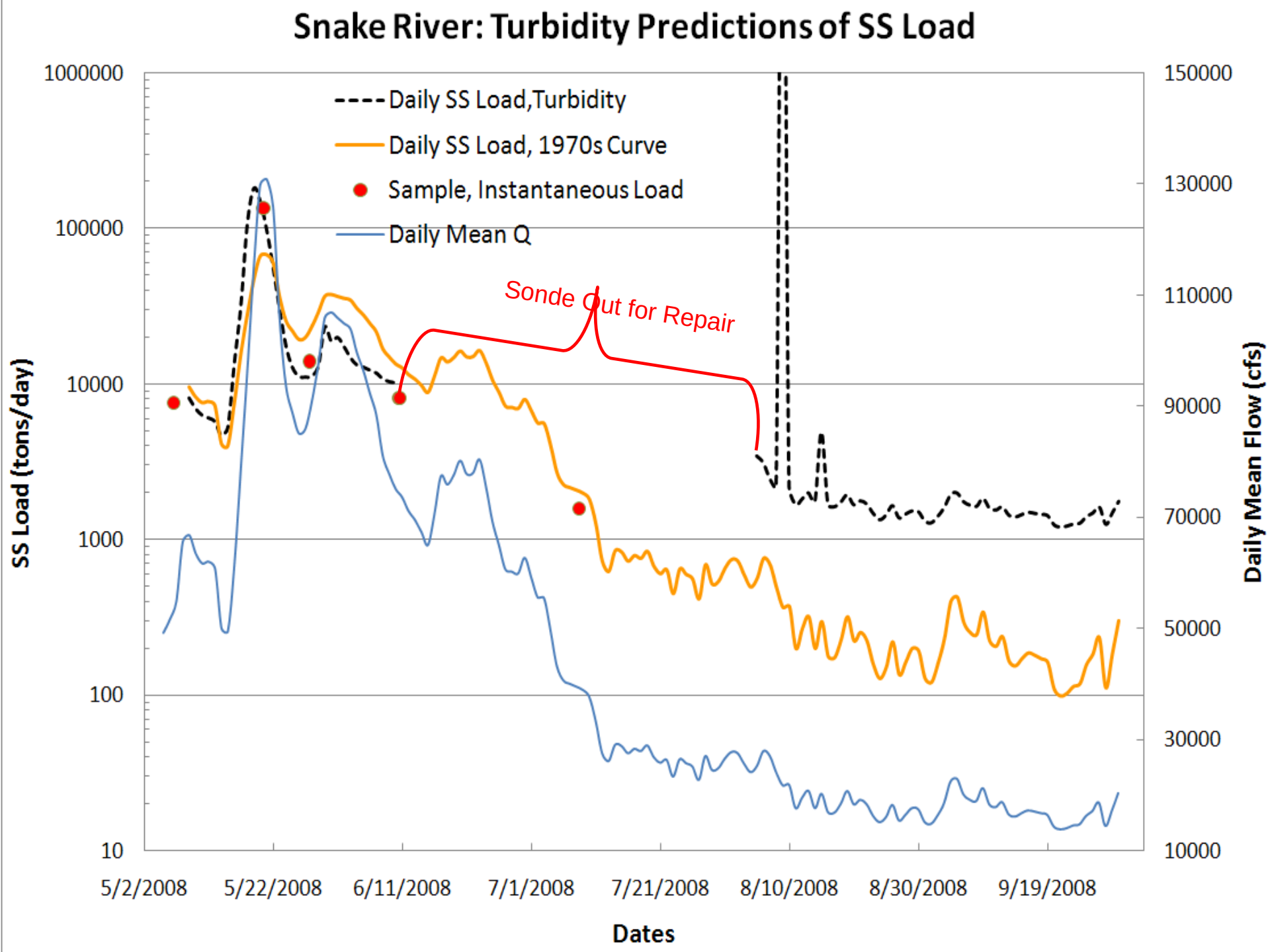

Turbidity
Log SSC = 0.012 (Turbidity) + 1.46
R² = 0.956
3.00
2.50
2.00
1.50
1.00
Log SSC
0
10
20
30
40
50
60
70
80
90
100
Turbidity (FNU)


Snake River Turbidity and Flow
Turbidity
Unit Value Flow
Sonde Out for Repair
Turbidity (FNU)
Flow (cfs)
Dates
0
100
200
300
400
500
0
20000
40000
60000
80000
100000
120000
140000
160000
5/7/2008
5/27/2008
6/16/2008
7/6/2008
7/26/2008
8/15/2008


Snake River: Turbidity Predictions of SS Load
Daily SS Load,Turbidity
Daily SS Load, 1970s Curve
Sample, Instantaneous Load
Daily Mean Q
Sonde Out for Repair
SS Load (tons/day)
Daily Mean Flow (cfs)
1000000
100000
10000
1000
100
10
150000
130000
110000
90000
70000
50000
30000
10000
5/2/2008
5/22/2008
6/11/2008
7/1/2008
7/21/2008
8/10/2008
8/30/2008
9/19/2008
Dates

Preliminary Summary - Snake

Surrogate	R^2	Average % Difference From Measured
Turbidity - SSC	0.956	-2.3%
1970's Sediment Curve	NA	-5.2%
2008 Discharge - SSC	0.830	+51.4%

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Overall Implications

- Increased accuracy?
- Greater temporal resolution of concentrations and loads
- Reduced sampling frequency
- Reduced O&M costs
- Safer
- Potential for real-time SSC estimates

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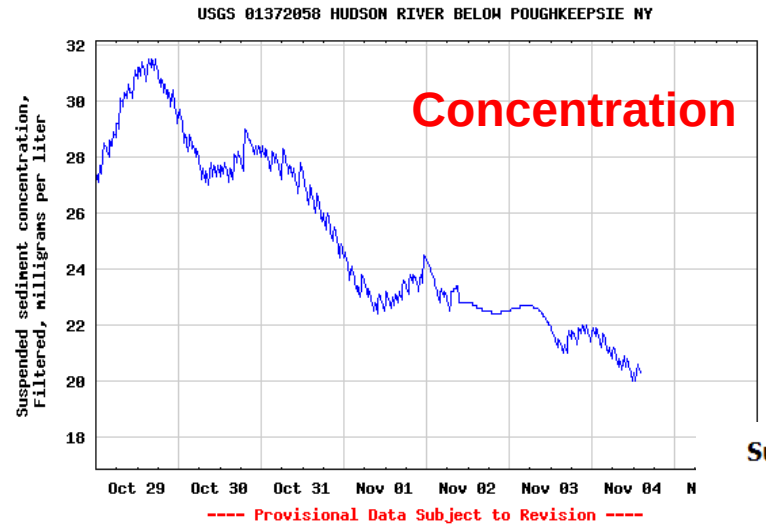
Example: Near-Real-Time Sediment

Suspended sediment concentration, Filtered, milligrams per liter

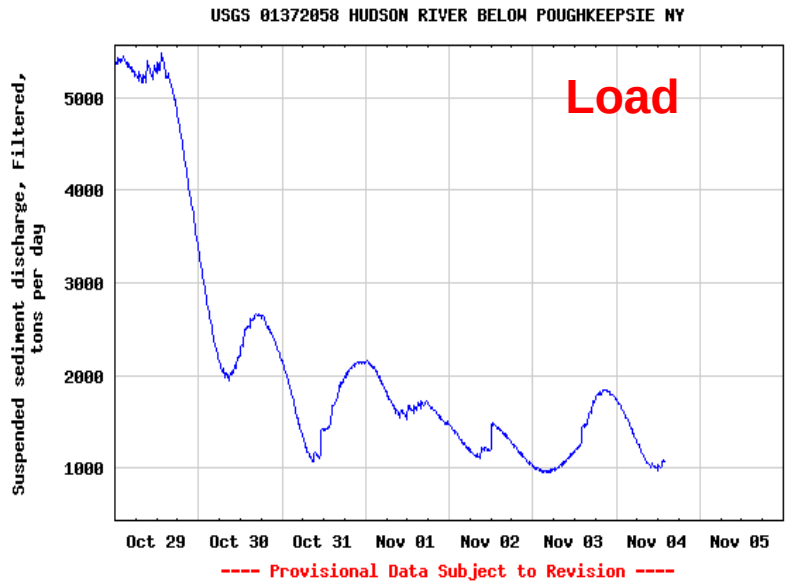
Most recent instantaneous value: 20.3 11-04-2008 14:00



Create presentation-quality graph

Suspended sediment discharge, Filtered, tons per day

Most recent instantaneous value: 1,080 11-04-2008 14:00



Courtesy: USGS New York, Lower Hudson River Project

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Project Website

http://id.water.usgs.gov/projects/surrogate_sediment/

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- NWIS Web
  - Current Conditions

Suspended Sediment Surrogate Technology Study on the Clearwater and Snake Rivers

Conducted in cooperation with US Corps of Engineers

Home > Studies in Idaho > Suspended Sediment Surrogate Technology

Data

Data from this study will be used to quantify and predict relative sediment contributions from the Snake and Clearwater River basins to the Lower Granite Reservoir. If relationships can be successfully developed between sediment concentrations and data from one or more surrogate technologies, predicted sediment concentrations will be made available on the web on a near real-time basis. As a result, sediment data would be available at a much higher temporal resolution than was previously available through the collection of periodic samples.

Clearwater River near Spalding, Idaho—13342500

Snake River at Anatone, Washington—13334300

See these sites on the study area map.

About this Study

- Introduction
- Study Area Map (new window)
- Methods
- DATA
- Publications
- Contacts
- To Learn More

Future Plans

- Proposed: acoustics on the Snake River
- Extend mounts
- Collect more information at mid- and high-flows
- Quantify cross-channel variability
- Continue to interpret data
- Journal article planned for FY2010
- Possible: near-real-time SSC

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Questions?
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